United States
Department of
Agriculture

Forest Service

Northeastern Area

Admin. Report
82-7

FOREST PEST MANAGEMENT REPORT

THE IMPACT OF STUNTING OF WHITE SPRUCE AT EVELETH, MINNESOTA

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INTRODUCTION

Stunting and purple discoloration of 1-0 red pine and white spruce seedlings (stunting syndrome) has been recognized as a significant problem in the Wisconsin State Nurseries and the USDA Forest Service Region 9 Federal Nurseries: Eveleth Nursery at Eveleth, Minnesota and the J.W. Toumey Nursery at Watersmeet, Michigan. In 1977, the Wisconsin Department of Natural Resources Nurseries at Hayward, Wisconsin Rapids, and Boscobel recorded 13, 18 and 23 percent respectively, of their 1-0 red pine seedlings were affected (Berbee et al. 1980). That same year, a similar problem was noted on both species at the Eveleth Nursery and on red pine at the Toumey Nursery. Stunting has continued to appear since 1977 at all five of these Nurseries.

The stunting syndrome becomes noticeable at the end of the first growing season. Affected seedlings have a purple foliage and are about one-half the height of the green non-affected stock. Portions of the beds that demonstrate these symptoms generally are poorly stocked with groups of healthy and stunted trees along the bed rows. Although the cause of the symptoms is unknown, the purple coloration of the foliage suggests a phosphorous deficiency (Armson and Sadreika 1979).

Because of the frequent occurrence of stunting, State and Private Forestry was asked by Region 9 to conduct a survey to determine the impact of stunting on production of white spruce at Eveleth Nursery. White spruce was selected for evaluation because it generally was more severely stunted than red pine.

OBJECTIVES

1) To determine the impact of stunting on growth and survival of white spruce at Eveleth Nursery. 2) To determine if soil nutrient deficiencies were associated with stunting of seedlings.

METHODS

Fifty percent of the beds with 1-0 white spruce were sampled in August, 1978. Disease distribution was determined by systematically selecting 6 sample points along each of the 26 beds in block 9. At each sampling point, a standard seedling inventory frame, 6 in x 4 ft (15 cm x 1.2 m), was used to delimit the seedlings to be examined. The total number of stunted seedlings and non-stunted seedlings were noted for each row. The distribution of stunted seedlings was then plotted.

Stunted and non-stunted seedlings were tagged for future evaluation. Ten plots of 24 seedlings (12 stunted and 12 non-stunted) were established in September, 1978. The height of the seedlings was measured at this time and recorded as first year growth. One and two years later, height and root collar caliper measurements were recorded. Upon lifting, the seedlings were graded by Nursery personnel to determine the percent cull associated with stunted and non-stunted stock.

To determine the dollar losses associated with white spruce stunting the number of stunted seedlings was multiplied by the percent cull (stunted percent cull minus non-stunted percent cull), this product was then multiplied by the 1981 cost per 1000 trees.

After the distribution of stunting was determined, stunted and non-stunted seedlings were collected and taken to the University of Minnesota, Research Analytical Laboratory for foliar analysis. Simultaneously, because the symptoms were those of a phosphorus deficiency, soil samples taken from beneath the stunted seedlings were taken to the Soils Department, University of Minnesota for analysis of pH, total nitrogen (N), phosphorus (P), and potassium (K).

RESULTS

Distribution of stunting by unit, sample point and row is given in Figure 1. Stunting was least severe in the northwest portion of the block. Based on stunting distribution observations for units 2 through 8, 28 percent of the 2.5 million 1-0 white spruce seedlings were affected.

The difference in first-year growth of stunted and non-stunted seedlings was dramatic. Stunted 1-0 seedlings were about one-half of non-stunted seedlings (Table 1). After two seasons, they were 42 percent as tall as non-stunted seedlings and 54 percent as large in caliper. At lifting, the average height of stunted seedlings had increased to 78 percent of that for non-stunted seedlings. A similar recovery was not observed for caliper. The average caliper of stunted seedling was 61 percent of that observed for non-stunted seedlings. No tree mortality was noted during the evaluation period.

Percent cull was 5 times greater in the stunted category when compared with the non-stunted seedlings (27.6 and 5.4 percent respectively). Based on the Eveleth Nursery 1981 cost per 1000 seedlings ($63.00), the percent cull due to stunting resulted in a $9,800 loss to the Nursery.

Table 1.--Average height and caliper measurements and percent cull for stunted and non-stunted white spruce seedlings, Eveleth Nursery.

	Height (cm)[1]/			Caliper (mm)[1]/		Percent[2]/
	1st yr.	2nd yr.	3rd yr.	2nd yr.	3rd yr.	cull at 3-0
Stunted	1.3	7.9	19.3	1.4	2.6	27.6
Non-stunted	2.8	19.2	24.7	2.5	4.2	5.4

[1]/USDA Forest Service, Region 9 Reforestation handbook stock specifications recommend a minimum height of 13 cm and caliper of 3 mm for white spruce at outplantings.

[2]/Cull due to failure to meet minimum height and caliper specifications.

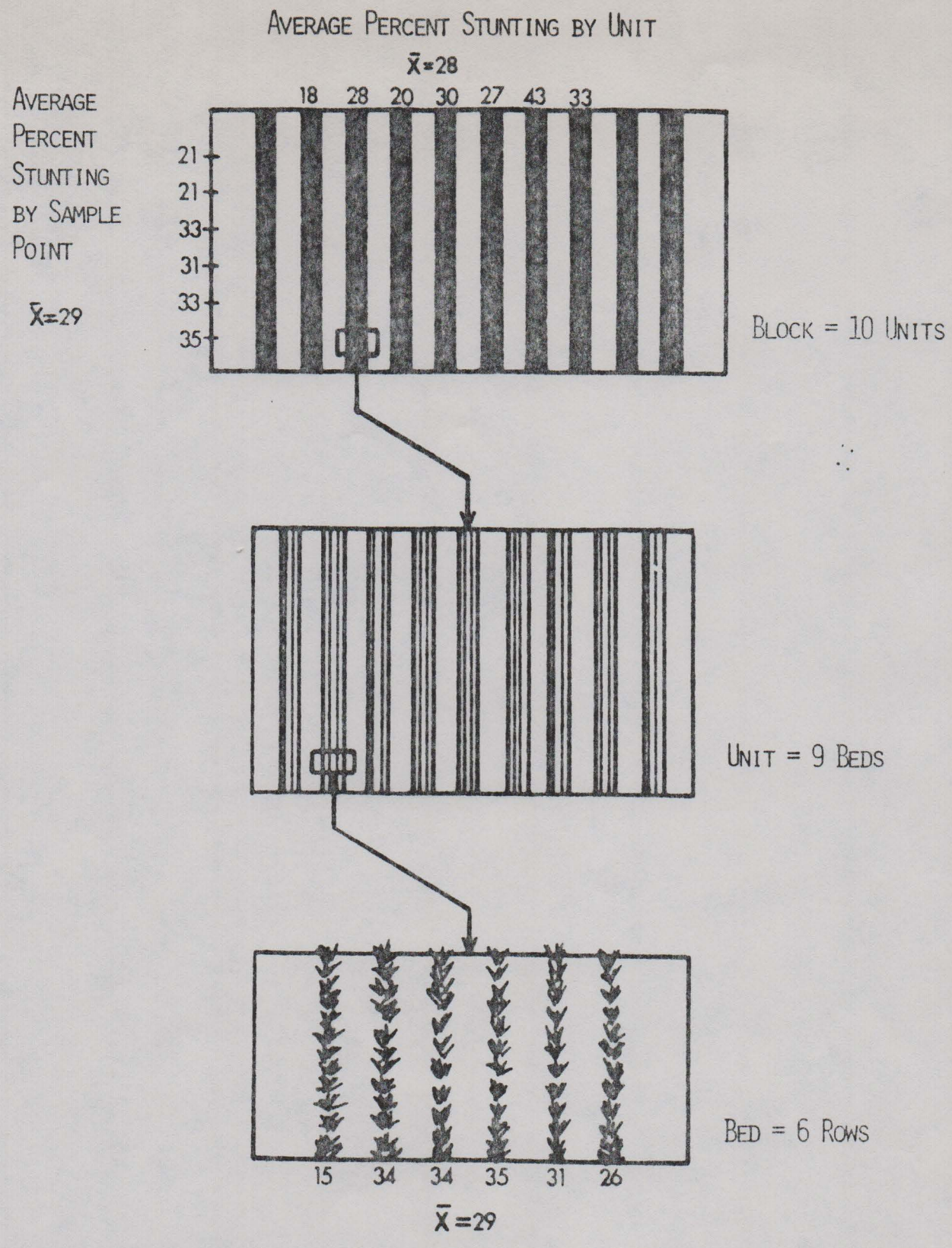

FIGURE 1 -- DISTRIBUTION OF 1-0 WHITE SPRUCE STUNTING IN BLOCK 9 AT EVELETH NURSERY, SEPTEMBER, 1978

Foliar analyses showed a marked difference in total N and P levels in affected and non-affected seedlings (Table 2). Stunted seedlings had 25 percent less N and 72 percent less P than non-stunted seedlings. The foliar analysis for other elements indicated no notable differences between stunted and non-stunted trees.

Table 2.--Mineral analysis of stunted and non-stunted 1-0 white spruce foliage Eveleth Nursery

	Mineral Content[1]/										
Seedling Condition	N (%)	P (%)	K (%)	Ca (%)	Mg (%)	Fe (ppm)	Mn (ppm)	Al (ppm)	Zn (ppm)	B (ppm)	Cu (ppm)
Non-stunted	2.07	.28	1.19	.49	.17	975	157	958	154	19	10
Stunted	1.51	.08	.87	.52	.19	1183	260	1340	120	30	5

[1]/All results are expressed on a dry-matter basis.

Soil samples from stunted and non-stunted plots showed no significant differences in levels of N (total), NO_3, P, K, and pH (Table 3). All samples were found to contain adequate levels of phosphorous, 200 lb/acre (224 kg/ha).

Table 3.--Concentrations of total nitrogen, phosphorous, potassium, and pH of soils assoicated with stunted and non-stunted white spruce seedlings, Eveleth Nursery

Origin of Soil Sample	pH	Total N(%)	P_2O_5 (lb/acre)	K (lb/acre)
Under non-stunted seedlings	5.20	1.37	200	197
Under stunted seedlings	5.76	1.00	200	219

DISCUSSION

The $9,800 loss presented here represents the situation at a specific nursery for a single year. Within the Lake States, stunting appears frequently on both red pine and white spruce, but in no set pattern. Stunting may occur year after year, or may disappear for several seasons and then reappear. The stunting episode outlined in this paper is not a rare occurrence. It is however, the first to be documented with dollar loss figures. The authors feel that these losses are significant, especially when the general occurence of this problem is considered.

This study did not follow trees into the field to evaluate the subsequent performance of the stunted seedlings. Although the average height of these seedlings had increased to 78 percent of that for the non-stunted trees, it should be noted that the beds had been top pruned. Therefore, stunted trees attained 78 percent of the top pruned height, not actual height. It is possible that stunted trees may continue to grow at a slower rate than their non-stunted counterparts. If this is true, dollar losses associated with the stunting of white spruce would be greater than those cited for this nursery evaluation.

The low level of stunting in the northwest portion of block 9 did not correlate with specific nursery practices or seed lots.

The purple discoloration and low foliage P levels of the stunted seedlings suggests that the stunting problem is associated with a P deficiency. The mineral analysis of the soil from portions of the beds that had stunted stock did not show corresponding low P levels. Therefore, it appears that factors other than soil nutrient content are contributing to this deficiency.

Phosphorous deficiencies may result from low soil pH values which inhibit the assimilation of P in plants (Brady 1974). At pH levels less than 6 P availability decreases with increasing acidity. Soil pH values under non-stunted and stunted seedlings were 5.2 and 5.76 respectively (Table 3). If pH was the limiting factor for P assimilation, the non-stunted trees would have had lower foliage P levels than the stunted trees. This, however, is the reverse of our findings.

The P deficiency noted here is not in agreement with the findings of Berbee et al. (1980). They analyzed the foliage both of red pine and white spruce and found no significant difference for P levels between stunted and non-stunted seedlings. No explanation can be given by the authors for this descrepancy in results.

No seedling mortality occurred during the period of this evaluation. However, it should be noted that there appears to be poor germination and/or survival during the first growing season in those portions of seed beds that have stunted seedlings. Our plots were established at the end of the first growing season. If mortality is associated with the earliest phase of stunting, it would not have been recorded in this evaluation.

CONCLUSIONS

1. Stunting was associated with phosphorous deficiency of seedling foliage inspite of the phosphorous-rich soils in which they were grown.

2. Stunted 1-0 white spruce seedlings do not show increased rate of mortality when followed thru the 3-0 stage.

3. Due to the failure of stunted 3-0 stock to meet grading specifications, significant dollar losses are associated with the occurrence of stunting.

RECOMMENDATIONS

1. A foliar and soil analysis should be conducted to determine if the phosphorous deficiency associated with stunting of white spruce is also associated with the stunting of red pine.

2. An investigation of the mechanism of phosphorous deficiency associated with stunting of white spruce should be pursued.

3. The long term effects of stunting should be evaluated by comparing the field growth rate of non-stunted stock with that of stunted stock that meets planting specifications.

LITERATURE CITED

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FIGURE LEGEND

Figure 1.--Distribution of stunting in 1-0 white spruce beds at Eveleth Nursery, September, 1978.